Concrete solutions towards sustainable construction

Double C-Block
Image courtesy of Luca Caruso

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Concrete forms the foundation of the construction industry, but to better our quality of life, we need to revisit our relationship with the built environment. How can we improve energy efficiency and, by extension, our way of life?

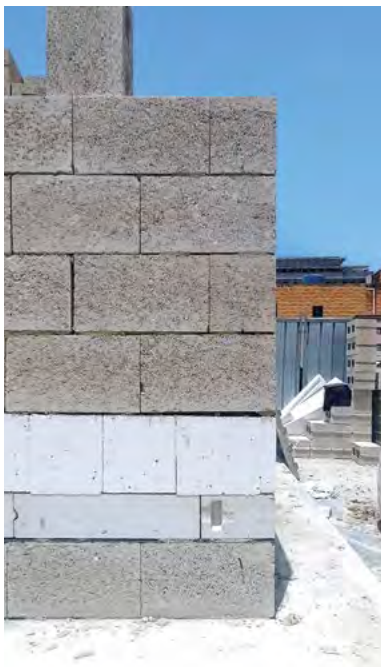
The Maltese Islands often feel like one huge construction site. The financial importance of the sector is massive. According to a study conducted by the NSO (National Statistics Office), the construction industry contributed over €545 million in 2020 to the local economy. To phrase it another way, construction is the only sector that grew in 2020 when compared to 2019, as it was the only sector that did not completely halt operations.

Urbanisation, one of the biggest causes of this phenomenon, is not expected to abate any time soon. By 2050, urban populations are estimated to double. But a quick glance at international headlines will reveal that the construction industry is facing some unprecedented challenges. As the world grapples with the implications of such issues as energy and water efficiency, waste reduction, and the need for implementing circular economy principles, research into more sustainable and greener construction practices seems like a no-brainer.

THINKING OUTSIDE THE BOX

Two researchers tackling these challenges in construction are the University of Malta's (UM) Prof. Vincent Buhagiar (Department of Environmental Design, Faculty for the Built Environment, UM) and Research Support Officer Architect Perit Luca Caruso (Department of Environmental Design, Faculty for the Built Environment, UM). Talking to THINK, Caruso explains that he has always been interested in sustainability within construction and he views it as his chance to give something back to the local community.

Buhagiar and Caruso have been working on a new type of concrete block, which they called the 'Double C-Block' (DCB), named after its geometry. Its special feature is that it maximises the path of heat transfer between its inner and outer skins, which minimises energy losses and makes it more efficient. The innovative idea has already garnered the support and funding from the UM and the Malta Council for Science and Technology.

As part of their experiment, the team constructed two concrete cells to determine the effectiveness of the Double C-Block. Images 3 and 4 show a test cell constructed of traditional Hollow Concrete Blocks, while image 5 (*opposite*) shows an identical cell built with a Double C-Block.
The ground and roof slabs were insulated with a 10 cm insulation board (*top left*) to ensure that most of the heat

'The use of modern concrete in construction has grown exponentially since its invention in the 19th century, and it is here to stay, thanks to the material's efficient and cheap qualities, as well as the speed of its creation', explains Caruso. 'However, as we become a more environmentally conscious society, we have come to realise that concrete comes with a few shortcomings in terms of its heat retention and acoustic qualities.'

Caruso goes on to explain that the most commonly used hollow concrete blocks (HCB), which have a standard, rectangular figure-eight shape, actually lose heat rapidly in winter and struggle to retain air-conditioned air inside buildings in summer. This is ultimately costly for inhabitants. He also explains that research into acoustic transmission suggests that the direct-bridged hollow shape also means that sound is often transmitted easily between party walls and inside buildings.

Cladding boards can be added to buildings to insulate them reducing these problems. Cladding can be internal or external, both are problematic. External cladding can cause problems if it takes place near the land boundary with other plots, whereas internal cladding eats into indoor floor space, which is never a welcome prospect for home buyers.

Caruso explains that, 'the idea behind this new concrete block was to create a composite material that would maintain the structural integrity of concrete without compromising on so-called "U-values" or the heat-transfer value.' U-Values measure the rate of heat transfer through a layered building material — the lower, the better. In other words, they measure how well the material insulates the house in summer and winter.

The new block addresses many of these issues. The new blocks are also more slender; standard load-bearing HCB blocks are mass produced at 230mm width, but the DCB is 200mm thick, which saves space without compromising its compressive strength. In addition, these researchers discovered that filling the Double C-Block with polyurethane insulation foam both acts as an adhesive that strengthens the concrete, keeping it from crumbling into pieces, and improves its heat-retention qualities. Research already indicates that thermal conductivity improvements also improve acoustic isolation.

TESTING THE THEORY

As part of an earlier M.Sc. research project by Luke Micallef, a prototype was developed and tested for thermal and acoustic properties as well as strength and resistance under laboratory conditions. Caruso enthused that the results of these tests were very promising, leading to the next phase of testing — seeing how the DCB performs in real-world environmental conditions.

'We have now joined forces with local HCB manufacturer Cementstone Manufacturing Company Limited to build two 20m² test cells. One was built using regular hollow concrete blocks and the other built in the new Double C-Blocks.'

According to Caruso, these rooms will be monitored over a twelve month period to determine their performance across the four seasons; the plan is to see the feasibility of the materials used and the DCB. Dr Simon P. Borg, Head of the Department of Environmental

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is lost through the walls. This allows the team to calculate how effective the Double C-Block is at insulating. Using materials with low thermal conductivity reduces the speed at which heat is lost. They also prevent thermal bridges, a phenomenon experienced when materials of different thermal conductivity are adjacent to one another.
Images courtesy of Luca Caruso

Design is co-supervising the on-site monitoring phase.

INDUSTRIAL IMPLICATIONS

The biggest obstacle the researchers face is the efficiency of producing these blocks. Currently, this is done manually, cutting the blocks by mechanical hand tools and patiently infiling the foam individually. Going from experimental to a more commercial interest would mean the creation of special moulds for the DCB, with other complementary machinery to facilitate the dry-casting and foam injection process. Production time is key to commercialisation, which would see the block's benefit spread through the construction industry leading to better buildings for people.

'We sincerely hope that this research will lead to a commercial product, possibly through a university start-up company. We also intend to continue analysing potential improvements to the DCB materials used, enhancing their properties, as well as investigating their potential for recycling. I hope that we will create a novel concrete block that at its end of service life, could be either reused (the best option) or recycled — by way of its biodegradable insulation and concrete, that can be re-engineered into new blocks for instance,' Caruso says with infectious enthusiasm.

'Our goal is to facilitate the exchange of knowledge between researchers and industry specialists and in so doing, find solutions that make environmentally conscious decisions more affordable.' Indeed, the team has an ongoing collaboration with the Department of Industrial Engineering under the supervision of Dr Arif Rochman, who is an expert in polymer testing. His assistance can help derive the ideal insulation design mix for a novel biodegradable foam that replaces the oil-based polyurethane.

Caruso goes on to explain how the idea for the blocks was a result of extensive brainstorming, creative thinking, and multiple attempts. 'Like Edison and his light-bulb,' he laughs, through trial and error, ultimately, persistence got him there. 'For us, it has taken several years to get to this point, but we can only hope that if we persist, such an energy efficient innovative block could gain ground with just as much popularity.'

Project R&I 2019 010T Double C-Block is financed by the Malta Council for Science & Technology, for and on behalf of the Foundation for Science and Technology, through the FUSION: R&I Technology Development Programme'. More info at this link: http://mcst.gov.mt/funded-projects-2017-till-date/

Further Reading

National Statistics Office Malta. (2021). *Gross Domestic Product: Q2/2021*, https://nso.gov.mt/en/News_Releases/Documents/2021/08/News2021_156.pdf

***Urbanisation worldwide | Knowledge for policy*. Knowledge4policy.ec.europa.eu. (2018). Retrieved 17 November 2021, from https://knowledge4policy.ec.europa.eu/foresight/topic/continuing-urbanisation/urbanisation-worldwide_en**